

# Delayed Response of Wild Japanese Monkeys by the Sand-digging Method (I)\*

— Case of the Koshima troop —

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## I. INTRODUCTION

When Itani (1958), using caramels, made an analysis of the food-taking process of the monkeys of the Takasakyama troop during 1954-55 which had not been provisionized long and not yet accustomed to other types of food from caramels, infant and juvenile monkeys under three years old were found to respond quite actively to this new kind of food. It was taken to at a high percentage. Data indicated more active responses among younger monkeys to the new situation and higher rates of adaptability, whereas older monkeys were found to be more conservative in behavior.

In contrast, the performance level of the intellectual behavior of monkeys and apes can be told by the extent to which they show new behavior patterns which tend to be more adaptive and advanced as they are confronted by a new situation. Köhler's *The Mentality of Apes* (1917) is in this sense a forerunner of such studies. In comparison, though similar data on Japanese monkeys are scarce, it is interesting to note that this type of behavior pattern is included in

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\*) Summary of this paper was reported by A. Tsumori under the title of "Confirmatory Analysis of Newly-acquired Behavior and Social Interaction of the Natural Troop of Japanese Monkeys" at the 131st AAAS Montreal Meeting held from December 26 to 31, 1964 at the "Symposium on Communication and Social Interaction in Primates."

which some Japanese ecologists call "the monkey culture or pre-culture". Kawamura (1954, 65), Miyadi (1959), and Kawai (1964, 65) made accounts of new behavior patterns that the monkeys of the Koshima troop acquired while adapting themselves to a new environment, that is, to the feeding ground, reported on how they came to acquire this behavior pattern and how it propagated among them. According to Kawai (1965) a behavior pattern of sweet-potato washing was acquired by almost all of the members of this troop in 1962 except for infants under 1 year old and adults over 12 years old. Adult monkeys are still immune to this specific behavior pattern although more than 10 years have passed since it spread. The wheat-washing behavior pattern—monkeys gather wheat scattered on the sand and wash it in water to separate the wheat from the sand—was acquired by the monkeys at the following rate: 2-3 years old—36%, 4-5 years old—75%, 6-7 years old—86%, 8-11 years old—25%, over 12 years old—0%. Quite contrary to Itani's result of his caramel test the monkeys of the Koshima troop scored good results in the 6-7 year-old group while the score of those over 8 years old sharply declined.

## II. THE FIRST SURVEY

For the purpose of obtaining some ideas about the following problems, the sand-digging test as described below was undertaken.

(1) What are factors which determine the behavior change observed in the problem-solving among the Japanese monkeys in a natural society?

(2) To find out prevailing ecological and social factors that influence the monkeys in their efforts to learn and perform intellectually.

### *Method of survey*

#### 1. *Sand-digging test*

The object of this test was to find out whether monkey can or cannot dig up the food which was buried in the sand. The experimenter digs a hole in the sand in the presence of a monkey and drops some food in it. The hole is covered up and carefully cleared of any external cue so that the monkey would lose track of the hidden spot. The sand-digging test may be a kind of a delayed-response experiment. To get hold of the hidden food the monkey has to form a substitutional implicit cue when every trace of external cue has been removed. It has to make appropriate responses directed by these substitutional cues otherwise it cannot get at the food. In nature the test was that of a delayed response, but it should be noted that we were unable to settle the constant delayed time.

#### 2. *Procedure of testing*

For test subjects were chosen the monkeys roaming freely about the Otomari beach, feeding ground. Tests were carried out in the following procedure:

(1) A monkey is chosen and lured to a spot where no other monkeys are found nearby. When the monkey approaches the selected spot the experimenter

digs a hole 6 cm deep. The monkey is forced to notice well the three peanuts which experimenter has in his hand while he is digging. The peanuts are dropped in and covered up immediately with sand. The surface of the hole is smoothed down to leave no betraying traces. The monkey is not allowed to come too near to the hole then. (We made it a rule to stop the test if the monkey approached to a distance of two or so meters.) When everything necessary for the test is done the experimenter draws slowly away from the hole. The monkey approaches the test site and the experimenter starts observation. The test is considered a "success" if the monkey manages to dig up the peanuts in about two minutes. The test is stopped and counted as a "failure" if the monkey displays no interest in it and goes away or takes more than the set time to dig the peanuts up. We carried out observations as long as possible, at least until the test monkey left the spot. At the same time other monkeys not under test were observed carefully to see what interest they showed in the test going on and how they behaved.

(2) Monkeys which failed twice in the ordinary test trials were as a rule given a training course, which involved giving some helpful external cues to them. The course consisted of six trials. In first five, all or a part of the peanuts were left clearly in sight or unmistakable external cues were presented while in the one remaining trial no external cues were given. If the monkey succeeded in this last trial, he was given an ordinary test trial. If the monkey failed in this last trial, he had to go back to another series of the special training course along with other monkeys that failed in the two ordinary tests.

(3) The criterion was three consecutive tests with success (correct responses). We made it a rule not to carry out more than two tests a day. The survey was carried out from August 13 to 29, 1962 over a period of 17 days on wild Japanese monkeys of the Koshima troop by the authors.

#### *Results of test*

##### 1. *Rate of sampling*

The Koshima troop at the time of the test consisted of 56 monkeys, of which 32 were males and 24 females. There were 7 adult males (including 2 leaders and 1 sub-leader), 6 adolescent males, 8 adult females, 9 adolescent females, 11 juveniles (male and female), 11 infants (male and female), and 4 solitary males.\*

Forty-one monkeys, that is 73.2% of the troop population were given in all 274 test trials including 30 special trainings (Table 1). Nine monkeys born that year and two 1-year-old monkeys could not be tested. Four solitary males remained outside the troop and could not be found during the test period. Tests were performed on all the other monkeys excluding the 15 individuals above

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\*) Age groups in which the monkeys are classified consist of six stages so fixed for the convenience of compiling data. (i) Infant stage: 0 to 1 year old. (ii) Juvenile stage: 2 to 3 years old. (iii) Adolescent stage I: 4 and 5 years old. (iv) Adolescent stage II: 6 and 7 years old. (v) Adult stage I: 8 to 11 years old. (vi) Adult stage II: more than 12 years old (refer to Table 1).

stated.

## 2. *Ratio of success*

Individuals that managed to dig out the peanuts within two minutes after the problem was presented were regarded as having "succeeded." "Ratio of success" represents the number of such "successful" individuals against the total number tested.

The ratio of success of the first trial was 43.9%. That is 18 monkeys out of 41 succeeded in the test trials. There were 7 out of 19 males and 11 out of 22 females that succeeded and the respective ratio of success was 36.8% and 50.0%. Difference according to sex is not significant ( $\chi^2=0.7167$   $df=1$   $0.5>p>0.3$ ) (Table 2). Table 3 and Fig. 1 show the ratio of success of the first trial, of the male, the female, and both put together respectively broken down in each age stage according to the classification given in Table 1.

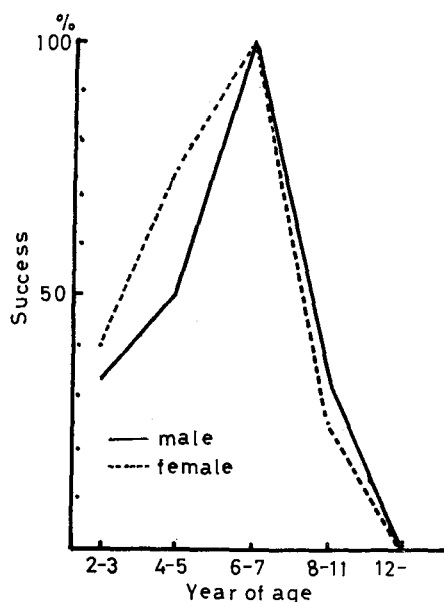
We can see clearly by this figure that in both the case of the male and the female the ratio of success rises with advancing age until the adolescent stage II (6~7-year-old stage)—of special note is the adolescent stage II wherein all the individuals have succeeded—and then starts dropping sharply from the adult stage onwards, and that all the individuals over 12 years old belonging to the adult stage II have failed ( $p<.001$ ).

Twenty-three individuals that did not show correct responses at the first trial were given altogether 192 test trials. As a result the ratio of success of the last trial rose to 78.0% (Table 2). Table 4 and Fig. 2 show the ratio of success of the last trial broken down in each age stage of the male, the female and both put together. We can see that the individuals of the juvenile stage, adolescent I stage, and adult stage came out with strikingly good results. Statistically the difference between the male and the female is of no significant ( $\chi^2=1.0116$ ,  $df=1$ ,  $0.5>p>0.3$ ).

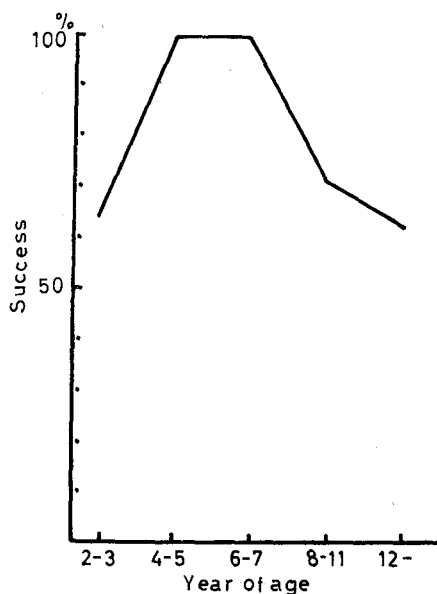
**Table 1.** Number of monkeys of each age stage and number of tested monkeys (Ss).

age stage	age (by year)	number of monkeys			number of Ss		
		male	female	total	male	female	total
infant	0~1	9	2	11	0	0	0
juvenile	2~3	6	5	11	6	5	11
adolescent I	4~5	4	4	8	4	4	8
adolescent II	6~7	2	5	7	2	5	7
adult I	8~11	6 (3)	4	10	3	4	7
adult II	over 12	5 (1)	4	9	4	4	8
total		32	24	56	19	22	41

Figures in brackets are numbers of solitaires.



**Fig. 1** Percentage of monkeys of each age stage succeeded in the first test trial



**Fig. 2** Percentage of monkeys of each age stage succeeded in the last test trial

**Table 2.** Percentage of monkeys succeeded in the first and last test trials.

	male	female	total
first trial	36.8 %	50.0 %	43.9 %
last trial	68.4	86.4	78.0

**Table 3.** Percentage of monkeys succeeded in the first test trial (by age stages).

age stage	2-3	4-5	6-7	8-11	over 12
male	33.3 %	50.0 %	100 %	33.3 %	0%
female	40.0	75.0	100	25.0	0
average	36.4	62.5	100	28.6	0

**Table 4.** Percentage of monkeys succeeded in the final test trial (by age stages).

age stage	2-3	4-5	6-7	8-11	over 12
male	50.0 %	100%	100%	33.3 %	75.0 %
female	80.0	100	100	100	50.0
average	63.6	100	100	71.4	62.5

We then classified the monkeys into five categories according to the rate of acquisition of correct responses respectively revealed in the test trials.

Criterion of the classification is as follows:

- A category: Individuals that succeeded in the first trial.
- B category: Individuals that succeeded in the second trial.
- C category: Individuals that reached the criterion only after having had one special training, which was given after they failed in two or more trials.
- D category: Individuals that failed in two or more trials and only reached the criterion after having had two special trainings.
- E category: Individuals that were tested in two or more trials and only reached the criterion after having had three or more special trainings and also those that failed in all the trials during the test period.

In Table 5 we have listed the names of the individuals of each category of each age stage. We can see that individuals in the 2~3-year-old stage are scattered throughout categories A, B, and E and in the 4~5-year-old stage distributed over A, B, and C, concentrated in A category in the 6~7-year-old stage, equally distributed over categories A, B, C, D, and E in the 8~11-year-old stage and clustered in categories C, D, and E in the 12-year-old or more advanced age stage. We can further see that the progress of the performance level of sand-digging shown in this table tends to consist with the curve of the ratio of success that results from the first trial shown in Fig. 1.

### 3. Behavior of the monkeys of each age stage

Characteristics of behavior of the individuals according to their age in solving the problem at the tests were:

#### *Infant stage (0 and 1 year old):*

There were nine monkeys born in 1962. They were 2~3 months old at the time of the test. They could not be led into the test situation. There were two 1-year-old monkeys. They were found to be strongly dependent on their mother. To separate them from their mothers or their same age groups and bring them into the test situation, was all but impossible. However, they were seen to watch their mothers at the test and make playful attempts at sand-digging. Of course such a behavior pattern can by no means be taken as the result of their having correctly comprehended the problem situation. There was no way to ascertain to what extent they had comprehended the problem situation, if they really had, and their ability to solve the problem.

#### *Juvenile stage (2 and 3 years old):*

It was an easy matter to lead the monkeys to the test situation. All the 11 individuals of this age stage came up for the test. *Eboshi*\* (2 years old), *Eso* (3

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\*) Signs on the right shoulder of names show either sex: A' is male and A' is female.

**Table 5.** Names of individuals of each age stage classified into five behavior categories which indicate the degree of process of performance level of sand-digging

	juvenile (2-3)		adolescent I (4-5)		adolescent II (6-7)		adult I (8-11)		adult II (12-)	
A	<i>Eboshi'</i> <i>Eso'</i>	<i>Tsuga'</i> <i>Ine'</i>	<i>Hamo'</i> <i>Ebi'</i>	<i>Tsuge'</i> <i>Ego'</i> <i>Nofuji'</i>	<i>Nabe'</i> <i>Tsuru'</i>	<i>Enoki'</i> <i>Zabon'</i> <i>Sasa'</i> <i>Nogi'</i> <i>Hama'</i>	<i>Ei'</i>	<i>Imo'</i>		
B	<i>Same'</i>	<i>Hasu'</i> <i>Zai'</i>	<i>Saba'</i>				<i>Aome'</i>			
C			<i>Ika'</i>	<i>Nashi'</i>			<i>Harajiro'</i>		<i>Hiyoshi'</i> <i>Akakin'</i> <i>Utsubo'</i>	
D							<i>Sango'</i>		<i>Kaminari'</i> <i>Eba'</i>	
E	<i>Nobori'</i> <i>Namazur'</i> <i>Namako'</i>	<i>Sakura'</i>					<i>Naki'</i> <i>Semushi'</i>		<i>Mobo'</i> <i>Natsu'</i> <i>Nori'</i>	

years old), *Tsuga'* (2 years old) and *Ine'* (3 years old) of A category succeeded in the first trial in 20~30 seconds. Of special remark were *Eboshi'* and *Tsuga'*. They were obliged to leave the test site temporarily because of avoiding a dominant monkey that approached the scene during the test. However, they came back later, responded correctly and solved the problem. *Same'* (2 years old), *Hasu'* (2 years old), and *Zai'* (3 years old), all of B category, failed at the first trial. They dabbled and dug in the sand near the hole. The responses were weak in strength and only a few attempts were made at the first trial to solve the problem, but they all succeeded in the second trial.

*Nobori'* (2 years old), *Namazur'* (2 years old), *Namako'* (3 years old), and *Sakura'* (3 years old) were no good as others of this stage in the test performance. At the first trial they merely approached the test site and sat down right in front of the hole. They gave the spot a glance, after which they kept gazing at the experimenter. No response whatsoever was made in the direction of the hole and in about 20 seconds they left the site.

*Nobori'* sat for six trials but remained utterly unconcerned throughout all the test trials. He left the spot in 5 or 6 seconds after each trial began. He did not seem to have any understanding of what the test was for. *Namazur'* went through 16 trials with no active responses whatsoever to the test situation. In four of 13 test trials for *Namako'* he reached out to touch the sand and in one he succeeded in getting the peanuts. *Sakura'* was quite an active individual but she depended strongly on her mother *Sasa'*. She had acquired many precultural behavior patterns but showed no good performance in the test. She went through 12 test trials, of which three were special trainings. She succeeded in two trials during

the test period, but that was not enough to reach the criterion. With a few more trials she might have reached the criterion, but we classified her into category E as she had too many trials already.

*Adolescent stage I (4 and 5 years old):*

The sand-digging performance level of the monkeys of this age stage was higher. As soon as *Ego'* (5 years old) and *Tsuge'* (4 years old) approached the test site, they went straight to the hole and started digging. They got the peanuts within 10 seconds. They went even further and dug around the hole for possibly more. *Ebi'* (4 years old), *Hamo'* (4 years old) and *Nofuji'* (5 years old) belonged to the peripheral part and showed some hesitation in approaching the site being afraid of other monkeys, but once they got there they went straight to the hole and dug out the peanuts in a short time. At *Ebi'*'s second trial he was attacked by *Ego'* when he had only two meters to go to the spot. He retreated 10 meters. Forty seconds later he returned, discovered the hole and got the peanuts after 30 seconds of sand-digging.

It is to be noted in these cases of juvenile monkeys, *Eboshi'* and *Tsuga'*, that despite quite a long delay period brought into the test by hindrance from other monkeys, they later succeeded in locating the correct spot and were able to carry the seeking behavior through to the end.

The behavior of *Saba'*, a 5-year-old male belonging to B category, was interesting to note, too. At the first trial he approached the site 10 seconds after the test started. He sat down on all fours, kept staring at the sand and left the site without any further response. Next day at his second trial he approached the spot again, sat down in front of the hole and kept watching the experimenter without showing any response whatsoever to the hole. Eighty seconds later *Ego'* came along and started digging around the spot where *Saba'* sat. Seeing what *Ego'* did, *Saba'* followed suit and succeeded in getting the peanuts 2 minutes and 10 seconds later. From the third trial on he located the hole accurately and with correct responses succeeded within 10 seconds. A similar case was also found with *Ika'* (5 years old, C category).

Whether the behavior of *Saba'* and *Ika'* was an imitated one is another matter, but the two cases do show critically that whereas the individuals in question could not find a way to solve the problem by themselves they were nevertheless able to unravel the thread by observing the behavior of other monkeys that were put in the same situation. It was also interesting to see such a behavior among the adolescent monkeys.

*Adolescent stage II (6 and 7 years old):*

This stage is one of the turning points of the monkey life. Male monkeys detach themselves completely from the central part of the troop and move into the peripheral part of the troop where they pass their lives as ordinary males. It is also at this time in this troop that they become solitary males. Females have her children and come to establish their female status in the central part of the troop.



We should note that of the monkeys belonging to this age stage seven two males and five females succeeded in the test at the first trial. Characteristic behavior of the monkeys of this age stage—they all approached the site immediately after the test began, made accurate locating of the hole and carried out a series of accurate digging responses in a short period. They required only 3~25 seconds, on average 8 seconds to arrive at the solution—a very short time when compared with monkeys of other age stages. They all succeeded in the second and third trials. Their responses became increasingly accurate with each test trial. Approaches or hindrances of other dominant monkeys did not affect the accuracy of their locating the hole nor their digging responses.

*Adult stage I (8 to 11 years old):*

Individuals of this stage tested were three males and four females. *Ei'* (8 years old) belonged to the peripheral part of the troop. He was uneasy and on his guard all the time but succeeded in the first trial although he may not have been exactly accurate in locating the hole nor very skilful in digging, for it took him 30~60 seconds to arrive at the solution. *Naki'* (10 years old) was an underdeveloped monkey. His body weight was 5.7 kg at the test time. He was about half the size of his companions of the same age and did not seem very much developed in behavior. He underwent 10 test trials, of which five were special trainings. He did not display a single response even in the way of sand-brushing or digging. His attention was constantly on the hands of the experimenter who after setting the problem situation would always find him at his heels when he turned back from the hole. This individual found the problem utterly incomprehensible. *Semushi'* (11 years old) was somewhat different in this point, but he was classified into the same E category. He sat through 11 test trials, of which four were special trainings. As *Naki'* did he was seen during the first half of the test trials threatening and attacking the experimenter and other monkeys near by after the peanuts were hidden. He showed no concern whatsoever about the hidden hole, and only after the third special training he responded somewhat by scattering sand. It was only after the fourth special training that he managed to dig out the peanuts without fail.

As to female monkeys we have here *Imo'*, a brilliant 10-year-old female. She was the first in this troop to learn the potato-washing behavior in 1953 when she was 1 and a half years old. It is interesting to note that among the female monkeys of this age stage only *Imo'* qualified for A category, although it took her somewhat longer than her companions of the adolescent stage to locate the exact spot the peanuts were hidden, and adopt the most appropriate reaction to arrive at the solution. *Aome'* (11 years old) failed in her first trial. She first proceeded to the spot alternatively looking at the sand and the experimenter. She reached out now and then to touch the sand, but left the test site in about 40 seconds. She managed well enough from the second trial on. She behaved more or less in the

same way as *Imo*' did. *Harajiro*' (11 years old) and *Sango*' (11 years old) showed no good performance. They failed in the first and second trials. They merely gazed absently at the experimenter and showed no response whatsoever to the hole. They left the test site in about 30 seconds. *Harajiro*' had to undergo one special training, and *Sango*' two to reach the criterion later.

*Adult stage II (over 12 years old):*

Four male and four female monkeys were tested. During the first two trials there were no goal-directed responses seen such as touching, brushing, or digging the sand. *Hiyoshi*' (adult) demonstrated a type of behavior which might be unusual in this stage. He walked around the hole for about 40 seconds, lingering at the site of this problem situation, whereas *Kaminari*' (No. 1 leader), *Akakin*' (No. 2 leader), and *Mobo*' (sub-leader) of the troop leader class unfailingly threatened the experimenter as soon as the peanuts were buried or attacked other monkeys nearby. None showed any interest to the sand and left the site in about 20 seconds although they were very eager to get the peanuts. It took *Hiyoshi*' and *Akakin*' one special training and *Kaminari*' two to succeed later. *Mobo*' was such a monkey as to have to go through 17 test trials, of which seven were special trainings, to reach the criterion.

The general behavior of female monkeys was more or less identical to that of the male. No goal-directed responses to the situation were seen in the first two trials. *Utsubo*' had to sit for one special training and *Eba*' for two to reach the criterion later. *Nori*', after three special trainings and *Natsu*', with 13 test trials, although only one was special, still failed in the finals and failed to reach the criterion. They were classified into E category.

### III. THE SECOND SURVEY

The purpose of this survey lay in finding to what extent was retained the previous sand-digging response the monkeys of this troop acquired at the first survey. The retention test was carried out about six months after the first survey. No monkey of this troop underwent any similar test during these six months. We reckoned that it should be possible for us to find out by this test the capacity of the monkeys to retain the previous sand-digging responses.

*Method of survey*

The retention test was done in exactly the same way as the first survey. Each individual was tested three times repeatedly but no more than one a day. No special trainings were in this time given to the individuals that had failed. They were carried out from February 23 to March 27, 1963, by Tsumori.

*Results of the test*

1. *Rate of sampling*

After the first test carried out in August 1692, *Utsubo*' died of old age and

the population of this troop and at the time of the test numbered 55 individuals, consisting of 32 males and 23 females. Three test trials were set aside for each individual, in total for 44 individuals (23 males and 21 females), 80% of the troop population. Eleven monkeys of the infant stage could not be led into the test situation independently. Consequently they could not be tested, but as four solitaries were moving in and out of the peripheral part all the individuals of this troop over two years old could be tested.

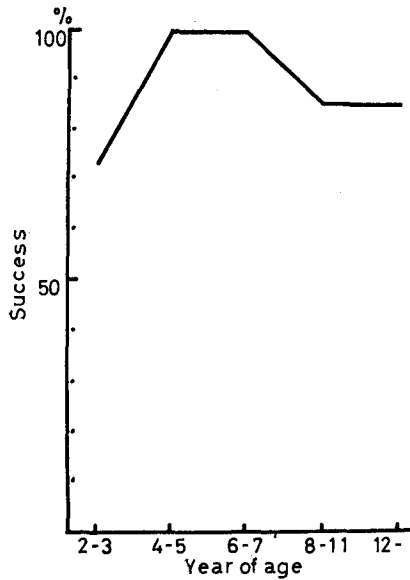
## 2. *Ratio of success and behavior of monkeys*

Table 6 shows the ratio of success respectively obtained at the three test trials. The male ratio of success of the first trial was 60.9%, 14 out of 23 having succeeded. The female ratio was 100% with all the 21 successful. Both put together the average percentage came to 79.5%. In the value of the ratio of success of male was included that of the solitaries which were not tested previously. Counting this out the male ratio of success comes to 73.7% and the difference between the sexes becomes significant ( $\chi^2=4,1389$ ,  $df=1$ ,  $p<0.05$ ). The total average was 87.5%—a result better than 78% obtained in the last trial of the first survey.

Table 7 shows the ratio of success of the first trial of each age stage according to the previous classification. Fig. 3 shows the total average of the ratio of success of the first trial of the male and female put together but excluding the four solitaries.

As to the test result of each individual we find that each, with the exception of *Ine'* and *Kaminari'*, respectively classified into categories A, B, C, and D to signify that they reached the learning criterion in the previous survey, succeeded in the three test trials. (*Ine'* failed once in the second trial and *Kaminari'* also in the first trial). Of the nine monkeys of E category, *Semushi'*, *Sakura'* and *Natsu'* succeeded in all the three test trials; *Nori'* failed in the second trial but succeeded in the other two; in comparison, *Namako'* and *Mobo'* showed no good performances—although they approached the hole they lacked accuracy in locating its correct position; some brushing responses were observed, but they were not sufficient to let them get the peanuts—they left off, completely losing interest in the problem presented. Quite by chance *Namako'* succeeded once in the third trial and *Mobo'* in the first. *Nobori'*, *Namaz'u'*, and *Naki'* seemed to do no better than they did at the previous survey. They were lacking in any understanding whatsoever of the situation. Their interest was directed mainly toward the experimenter. No goal-directed responses were shown toward the sand. They failed all the three trials.

Four solitaries sat for the test for the first time but failed in all the three test trials. *Nomi'* (9 years old) did nothing but threaten the experimenter when he hid the peanuts in the sand. *Ita'* (11 years old) kept shifting his eyes from the sand to the experimenter. He attempted a few touching gestures at the sand in the vicinity of the hole but left the site in 20~30 seconds. *Hanakake'* (full adult) rudely walked off right away as soon as he saw the peanuts buried and did not even try to make an attempt to solve the problem. *Kon'* (11 years old) sat near



**Fig. 3** Percentage of monkeys of each age stage succeeded in the first test trial.

**Table 6.** Percentage of monkeys succeeded in each test trial.

	male	female	average
first trial	60.9 (73.7)%	100 %	79.5 (87.5)%
second trial	60.9 (73.7)	90.5	75.0 (82.5)
third trial	65.2 (78.9)	100	81.8 (90.0)

Figures in brackets show the percentage except that of four solitaries who were not tested in the first survey.

**Table 7.** Percentage of monkeys succeeded in the first test trial (by age stages)

	2-3	4-5	6-7	8-11	12-
male	50.0	100	100	33.3 (66.6)	60.0 (75.0)
female	100	100	100	100	100
average	72.7	100	100	60.0 (85.7)	75.0 (85.7)

the hole at every test and did some touching and brushing behavior, but he could not locate the hole accurately and attempted only a few response, eventually walking off in 30~40 seconds.

These results show in general that the sand-digging behavior which the monkeys acquired during the course of problem-solving at the first survey was sufficiently retained even after six months. Generally speaking and as compared with the first survey the monkeys were found to be more accurate in the digging response and in locating the correct position of the hole. They responded more accurately and required a shorter time for the solution. Compared with the first survey there were more obstructions from monkeys which were not being tested, but the failure of hardly any of the 28 unsuccessful cases can be attributed

to this cause. Of 104 successful test trials 78 were carried out without seeing any attempt of other monkeys to approach the test site. The time required for the solution was 1~53 seconds, 6 seconds in median. In 26 test trials other monkeys approached the test site. Such monkeys consisted chiefly of dominant monkeys that took to threatening and attacking. In such cases, the time required for the solution ranged from 7 to 96 seconds, median being 43 seconds—an exceedingly long time. When dominant monkeys approached their companions on test and threatened them away, they first took to their heels but returned later to the test site and continued digging from where they left off and succeeded. Though some monkeys, hampered by other monkeys, had to leave off for quite some length of time during the test, they, nevertheless, kept hold of implicit or external cues very accurately and successfully. In contrast, the individuals that ended up in failure at the first survey without showing any sign of solving the problem (*Nobori*, *Naki*, and *Namazur* of E category) fared similarly in these three test trials, failing to succeed in every single test trial. It was interesting to note that *Namazur*, *Naki*, and *Namako* (the last mentioned succeeded in only one trial) were the children of *Nami* (KAWAI 1965).

## DISCUSSION

From the results of the sand-digging tests performed by the wild Japanese monkeys of the Koshima troop, what we find most remarkable is that the ratio of success rises with advancing age, reaching its peak in the 6~7-year-old adolescent stage and then dropping sharply with further advance in age. We will now attempt an analysis of the problem solving mechanism that functioned in the sand-digging test and see whether such tendencies can be explained.

The solving pattern of behavior of these tests may be considered to consist of four components. The first is a motivational factor directly brought out by the incentive, the peanuts. The second is a perceptual differentiation factor which is formed in the monkey when it confronts a stimulus object. The third is a factor of ability which retains the differentiated cue over a delay period. The fourth is a technical factor which, based on this cue, compels the monkey to use its hands as a tool to dig the peanuts out of the sand.

### 1) Motivation:

Regarding the degree of intensity of motivation towards the peanuts all the individuals, excepting of course the baby monkeys under 1 year old, may be regarded as having been just about equal. Peanuts are one of the foods most liked by the monkeys. They have been eating it all these 10 years ever since they were provisioned. We may say that all the monkeys tested saw the peanuts as equal in value. We could not ascertain at the time of the test how hungry the monkeys were, but if there did exist any difference in the degree of their craving for the peanuts before or after having eaten at the feeding ground, there was at least no evidence of any apparent difference such as to have observed during the test. Therefore, the motivational level of the monkeys with regard to the incentive or the reward at the time of the test could not have varied so much as to have influenced the results of the tests.

### 2) Ability to differentiate perceptual cues

How proficiently this ability may grow with the advancing age of the monkeys or how it may deteriorate is in itself a very important problem, but the tests could not tell this directly. A study by Harlow et al. (1960) on rhesus monkeys shows that as months pass the ability of the monkeys to learn comparatively simple problems such as "object discrimination" improves until they reach the age of about one year old and attains asymptote even after this age period, while with more difficult problems such as "learning set formation" and "patterned string performance" (MASON and HARLOW 1961) asymptote is attained at a more advanced age period: this ability keeps improving until the 4~5-year-old stage. Though the nature of the problem is somewhat different, Kawamura (1961) reports in his research on the Koshima monkey troop that adult monkeys surpass juveniles in the test to make use of discarded paper bags in which wheat was contained.

Would then this ability deteriorate with the passing of the adolescent stage

and the coming of the full adult stage? In the report of Mason et al. (1964) on chimpanzees (7 to 41 years old) no difference was observed among younger and older chimpanzees in object discrimination and serial discrimination test results.

How the ability to differentiate cues varies with age depends in part on the difficulty of the problem. A conclusive answer to the problem cannot be found easily. It all depends on how difficult it is to differentiate the perceptual cues that are necessary to solve the sand-digging test. The juveniles, *Eboshi* and *Tsuga*, showed accurate responses at the first trial. This leads us to presume to solve a simple sand-digging test a comparatively low level of cue differentiation ability is sufficient, as compared with solving a "learning set formation" test, etc. Apart from infant and juvenile monkeys, the test results of which showed improvements in this ability, it is at any rate difficult to interpret in terms of this factor alone why the test results of adult monkeys over 8 years old showed a deterioration of the ratio of success.

### 3) Ability to retain differentiated cues

We first thought that the sand-digging test would serve as an index of the performance level of the intellectual behavior of the monkeys, because to succeed in the tests it was necessary for them to retain and last through a delay period until the peanuts were secured implicitly substituted cues derived from external cues obtained at the time the problem had been presented, and furthermore because one of the important roles played at the time the problem was to be solved was a symbolic process. However, these test results cannot be said to be a direct proof of such an ability of Japanese monkeys. Results of delayed response experiments show that adolescent macaques, according to Harlow et al. (1960), are more proficient than infants, and older chimpanzees that have reached maturity, according to Mason et al. (1964), are inferior to younger ones. From such data and from the analysis of the behavior of the monkeys in our sand-digging tests we may find that this factor accounts to some extent for the apparent difference varying with age as seen in the test results.

### 4) Technique of sand-digging

It can be safely said that no difference in this technique of sand-digging was observed at least among the monkeys over 2 years old that were tested. That is, any monkey of any age stage was at any time capable of eliciting a digging response as long as there were external signs which clearly indicated the spot where the peanuts had been buried.

Of the above four factors that constitute the sand-digging behavior, the factor of ability to differentiate perceptual cues and the factor of ability to retain the cues seem to account for the causes that bring about the changes in test results in accordance with age. It is assumed that the latter plays a larger role than the former as the main factor which deteriorates largely the rating of adult monkeys, especially those over 8 years old.

Apart from various factors that make up the sand-digging behavior we must also consider other factors. It has been observed that while adult monkeys over

8 years old were strongly attracted to the peanuts, they displayed only small interest in the sand-digging problem. This tendency was seen to be especially strong among the adult males. No definite answer can be given at present as to why they did not fit in the problem situation, but it could have been a social factor, that is, adult and dominant monkeys may not care about getting rewards by solving the test problem as they have other means of getting food. In other words, they can always resort to threatening or attacking the experimenter or other monkeys and rob them of their food. We even observed some dominant males which took to following every monkey that underwent tests and robbed them of the peanuts they got by solving the problem. That is to say, to these monkeys that have acquired such a behavior pattern sand-digging tests may have lost their meaning.

We may further assume that such conservatism traits as were strongly observed among the older monkeys in Itani's (1958) caramel test previously referred to tended to make the attitude of the adult monkeys all the more conservative towards a novel situation as these sand-digging problems presented. This conservative attitude of adult monkeys may be due to the fact that they had no experience in being provisioned in his juvenile stage.

We will now dwell a little on the results of the retention tests of the second survey. The tests were unexpectedly well retained and the solving behavior by digging response showed improvement. Having no control data, it is impossible for us to say anything definite yet as to how long can be retained a behavior pattern once acquired in such a situation as sand-digging. We may add the following episode. As explained previously nothing whatsoever was done during the past six months in the way of reinforcing the digging response nor was there any habit to be observed in this monkey troop of digging up and gathering roots or subterranean stems as was commonly seen in the daily lives of the monkeys of the Minoo-B troop and Takagoyama-A troop (Kawamura, 1965). When no more wheat was to be found on the sand at the feeding ground they dug up the sand, anticipating that it might be in the sand. Such a behavior of gathering became quite wide-spread among the monkeys after the first survey. This could be so interpreted that the sand-digging behavior acquired in the sand-digging test had become generalized and was applied to wheat gathering which in turn served to reinforce the sand-digging response and maintained it on an increasing level until the second survey came on.

Sex difference was found in the second survey. Can not this be explained by the fact that male monkeys are exposed to more interference than female monkeys are in their activities during the delay period, the test itself being of nature a delayed response test?

Another point that should be considered in is the fact that the tests were performed out-of-doors. The tests supplied us with informations as to what kind of attitude each monkey would take and how it would behave when it was faced with a similar problem situation in wild life, that is, in natural society. It was



of course impossible to prevent directly and completely hindrances by other monkeys not being tested, but we may say that indirectly not only the social conditions and social status of each monkey but also many other uncontrollable factors played their parts in influencing the behavior of each monkey. It, therefore, is necessary for further verification to have laboratory tests made where these factors can be controlled. Likewise, similar tests on other troops living in different social and physical environments would certainly produce further interesting results and data. If such data wherein the conditions are controlled and other data on other troops had been available, it might have been possible for us to understand better the mechanism of the intellectual behavior of the monkeys in a wild environment and also the ecological and sociological factors that influenced their behavior.

By comparison the ecological conditions and the social organization of the Koshima troop seem to be more favorable than those of other troops in the way of better development of intellectual behavior. That the population of the troop was comparatively small, that kinship relations facilitated better intercommunication, that the members possessed many newly-acquired behavior patterns and maintained such in common on a "precultural level" as already referred to in the introduction seem to have favorably affected the monkeys, along with other factors, in the test solving. We will refrain from referring further here on these effects of ecological and social environments and discuss them at the next opportunity in a paper dwelling on sand-digging tests of Takasakiyama troop and Ohirayama troop monkeys.

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#### *SUMMARY*

1) Sand-digging tests were carried out to find in part psychological characteristics of the monkeys of the Koshima natural troop.

2) The test might be a kind of a delayed response experiment, and it was expected that a symbolic process, that is, a part of their intellectual behavior would be revealed.

3) During the period August 13-29, 1962, 274 test trials were carried out on 41 monkeys representing 73.2% of the population (the first survey).

4) The ratio of success in the first trial was male 36.8%, female 50.0% and in total 43.9%. The percentage of the total rose to 78.0% in the last trial. A remarkable learning effect was observed with the monkeys.

5) Divided in each age stage there was a remarkable rise in score from the juvenile stage to the adolescent stage. They scored 100% especially in the 6~7-year-old stage but deteriorated rapidly on entering the adult stage and finally fell to 0% in the age group consisting of monkeys of 12 years old or more.

6) Retention tests on sand-digging behavior were carried out six months after the first survey, that is, from February 23 to March 27, 1963 (the second survey).

7) At the first trial of the retention test the males scored 73.7%, females 100% and in total 87.5%. We found that the sand-digging response acquired at the first survey was not only fully retained but was also more accurate and skilful than at the previous survey.

8) We studied various factors that made up the sand-digging behavior and have been able to state a result that of these factors the ability to differentiate perceptual cues and the ability to retain differentiated cues played important roles. At the same time we also mentioned that the influence of an indirect factor, a conservative tendency that showed strongly among the older monkeys was not to be disregarded.

9) As these tests were performed out-of-doors we presume that not only the factors ruling each individual but also various other factors such as population, social status, pre-culture, and ecological environment of the troop had their roles to play which also influenced the behavior of each monkey. It has, therefore, been made clear that to analyze the intellectual behavior of wild Japanese monkeys in a natural troop, it is necessary and important to have two kinds of data derived from analysis of ecological and social factors and from a laboratory study which excludes these factors.

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